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DECOMMISSIONING STRANDED ENERGY ASSETS – A USD 8 TRILLION CHALLENGE

BNP PARIBAS
ASSET MANAGEMENT

The sustainable investor for a changing world

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WHAT IS 'DECOMMISSIONING'?

Decommissioning refers to the process of retiring and dismantling an industrial facility, such as a nuclear power plant, a mine or an offshore oil rig, at the end of its productive life to return the site to an environmentally safe and fully rehabilitated condition.

What is at stake?

Based on in-house estimates and a recent study undertaken by BNP Paribas Asset Management (BNPP AM), the global cost of decommissioning oil & gas, nuclear, traditional and renewable energy, mining, industrial, waste management and shipping assets could reach almost USD 8.0 trillion over the coming decades.

The nuclear, renewable energy and mining sectors are the most expensive to decommission, while Asia, Europe and North America have the highest decommissioning costs by geography. Putting the nuclear sector aside, over USD 5 trillion of liabilities are pre-funded for their retirement and thus fully rely on the solvency of their owners (and in some cases their insurer) when the liabilities become due.

Why it matters to everyone, especially in the context of the energy transition

The intensifying focus on sustainable, environmental, social and governance (ESG) activities and the energy transition mean decommissioning obligations are becoming more significant for companies and investors alike. Companies failing to account for such environmental and ecological risks may face reputational damage and financial losses, especially since many have endorsed the pledges of the Paris Agreement and have started to implement sustainable and energy transition policies.

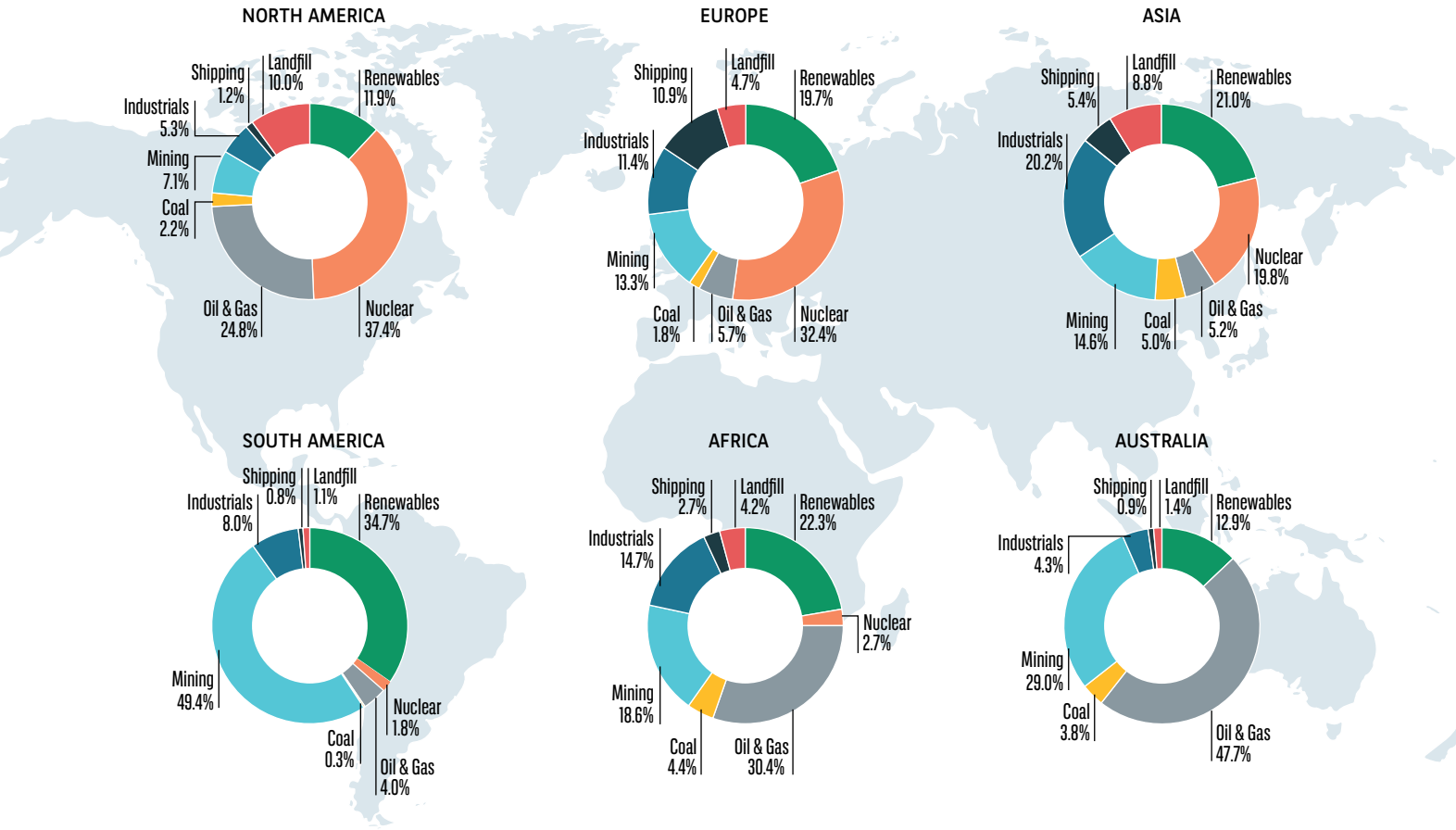
What can be done to mitigate the risks?

Pre-funded decommissioning reserves – funds set aside over the operating life of a facility to cover anticipated decommissioning costs – provide companies with a reliable and predictable source of funds to meet these long-term liabilities. Using the same principles as pension funds for employees, pre-funding reduces the risk of a financial shortfall and the need to rely on government or taxpayer support. Such an approach can help companies fulfil their environmental and financial obligations to ensure a sustainable future for all.

The purpose of this document is to raise awareness of the decommissioning challenges around the world. This issue is often overlooked or underestimated by companies and governments as it is considered to be a problem to be addressed long into the future. However, with the energy transition gathering pace in recent years, many decommissioning liabilities may become due far earlier than expected.

There are no safety nets should companies fail to meet these obligations: this document will show that there are limited funding reserves to guarantee that this multi-trillion dollar challenge is met, while many ecosystems and the health of many communities worldwide are at stake.

Exhibit 1: Split of decommissioning costs by sectors across regions



Source: BNP Paribas Asset Management, March 2023

INTRODUCTION

The purpose of decommissioning is to return worked-out industrial sites to a condition that is environmentally safe and available for rehabilitation. Decommissioning is thus a crucial part of the energy transition and the commitments of many corporations, countries and governments to a more sustainable, low-carbon future.

However, decommissioning can be costly and complex, often requiring specialised skills, technologies and equipment. If old and outdated facilities are left unattended, there can be significant environmental and health risks. In addition to these societal risks, companies may not be able to meet the decommissioning costs from their operating cash flows. Beyond the obvious reputational risk, sub-par decommissioning can have adverse environmental impacts. It is thus important to ensure that the decommissioning phase benefits from adequate financial resources. This means companies should set aside enough funds during the operational life of the facility to cover all the future decommissioning costs.

Pre-funding decommissioning liabilities can help reduce the risk of a financial shortfall for the companies involved, as well as for governments and taxpayers. It enhances transparency and accountability in the sectors involved in decommissioning, while mitigating the negative impacts of stranded assets and environmental liabilities.

In 2020, we estimated worldwide decommissioning costs/liabilities totalled USD 3.6 trillion[1]. This paper re-evaluates the total liabilities given increasing global regulations and standards on ESG and the corresponding changes to business operations. Furthermore, we include the decommissioning liabilities and asset retirement obligation estimates for the renewable energy, shipping, industrial and landfill sectors in addition to the sectors included in the first paper (nuclear, coal power, mining and oil & gas).

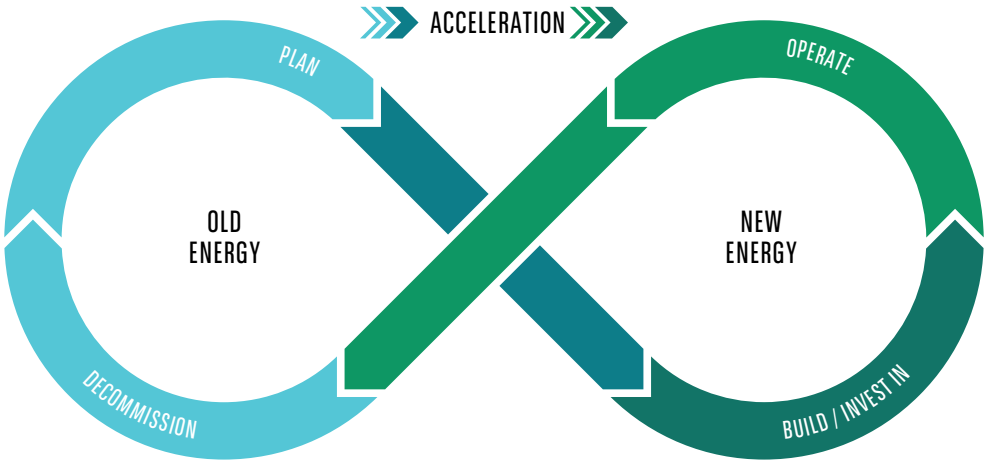
In the first section, we discuss the importance of decommissioning for the energy transition. In section two, we present the scale of the decommissioning liabilities. In the third section, we highlight how decommissioning is currently managed, the risks of not pre-funding decommissioning, and why decommissioning pre-funding is becoming more critical in the context of an accelerated energy transition. Finally, in section four, we discuss pre-funding solutions and their benefits.

1. Decommissioning: a USD 3.6 trillion challenge. BNP Paribas Asset Management, 2020. Available from: https://docfinder.bnpparibas-am.com/api/files/65DC8307-F884-47B9-BE20-660DB337B978

DECOMMISSIONING IS A CRUCIAL PART OF THE ENERGY TRANSITION

The energy transition is the ongoing shift in energy supply and demand from fossil fuels to sustainable sources, 'renewables' such as solar and wind power with low carbon emissions. This transition is essential if the global community wants to successfully reduce greenhouse gases to zero by 2050 and manage global warming. Decommissioning is a crucial aspect of the energy transition because it involves the complete or partial closure and disposal of outdated and polluting infrastructure.[2] The effective retirement of old, inefficient energy assets helps reduce greenhouse gas (GHG) emissions. Power plants, for example, typically emit substantial amounts of carbon dioxide, sulphur dioxide and other pollutants that contribute to climate change. As the world develops new infrastructure, it is vital that redundant and polluting assets be retired, removed, repurposed or retrofitted simultaneously. Decommissioning becomes part of the new energy system and serves as a 'green' investment. It enables the reuse and recycling of materials and components, reducing waste and promoting circular economy principles.

Exhibit 2: The energy transition cycle



In this respect, there must be a clear distinction between old and new forms of energy. Under the old energy system, infrastructure assets generally produce high emissions, have 40+ years of operating life and can take more than eight years to plan and build.[3] These assets involve investments in similar technologies which replicate the existing operational infrastructure. Additionally, these polluting assets can be decommissioned long after they stopped operating. In contrast, new forms of energy infrastructure:

- Have about 20+ years' operating life[4]
- Use cleaner sources
- Require continuous replacement
- Are often built on pre-existing assets
- Require investment in new technologies.

These differences show that new energy forms offer more economic benefits in terms of promoting innovation to achieve zero emissions. The speed at which the energy sector can cycle through the transition depends on how smoothly it can meet the financial challenges of decommissioning (see Exhibit 2).

2. Source: BNP Paribas Asset Management, Ruediger Koenig, November 2021
3. BNP Paribas Asset Management, 2023
4. See Table 2 in the appendix (hydro energy is the exception with generally a much longer lifespan)

THE USD 8 TRILLION GLOBAL CHALLENGE OF DECOMMISSIONING THE EXISTING INFRASTRUCTURES

SUMMARY OF THE DECOMMISSIONING LIABILITIES ACROSS THE EIGHT SECTORS

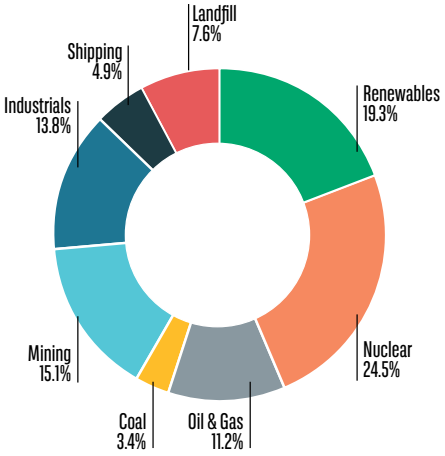
Table 1: Estimated decommissioning costs across sectors in respective regions for the existing infrastructure

(USD bn)	Renewables	Nuclear	Oil & gas	Coal	Mining	Industrials	Shipping	Landfills-waste	Total
Africa	39	5	53	8	32	26	5	7	175
Asia	799	753	199	190	555	769	206	333	3,805
Australia	16	0	60	5	37	5	1	2	126
Europe	280	461	81	26	189	161	155	67	1,421
North America	234	732	486	44	138	103	24	195	1,956
South America	177	9	20	1	252	40	4	6	509
Total	1,544	1,960	899	274	1,203	1,105	395	611	7,991

Source: BNP Paribas Asset Management, 2023

The **nuclear sector** accounts for the largest portion of global decommissioning costs at 25% (see Exhibit 3). This is due to the high costs of closure, decontamination and in demolition, radioactive waste management, and long-term monitoring needed for nuclear sites. In addition to the decommissioning obligations for civilian nuclear power plants, the costs of dismantling older military nuclear facilities have also been estimated. These may or may not follow the same decommissioning processes as conventional nuclear power plants.

Exhibit 3: Total estimated decommissioning liabilities by sector



Source : BNP Paribas Asset Management, 2023

The **renewable energy sector** ranks second highest in global decommissioning costs with hydroelectric dam renovation accounting for 83% of costs and the rest accounted for by solar and wind turbines. Most US and European dams were built between 1930 and 1970 with a design life of 50 to 100 years [2], so at least 50% of them will need significant rehabilitation or removal in the next 30 years. Furthermore, with more wind and solar farms being built in the coming years in the context of governments' net zero obligations, decommissioning costs in the renewable energy sector are likely to rise significantly in the near future.

For the **mining sector**, the data covers hard coal, lignite, non-ferrous metals and metal ore mines. It is worth noting that in the case of mining, beyond the closure of the mines themselves and the rehabilitation of the surrounding land and waterways, one of the critical issues is the closure and decommissioning of tailing storage facilities. Tailings hold process water and fine-grained solid materials that remain after the recoverable metals and minerals have been extracted from the treated ores and have been placed in a containment area[3]. From our analysis, Asia has the largest decommissioning liabilities, followed by South America (see Table 1), reflecting the high level of mining activity in these regions.

Our analysis estimates **industrial decommissioning** costs using proxies for chemical plants and heavy industries. China alone accounts for 40%[5] of total industrial decommissioning costs, making Asia the top region with a total of about USD 770 billion. North America and Europe are the next largest, at more than USD 100 billion each (see Table 1).

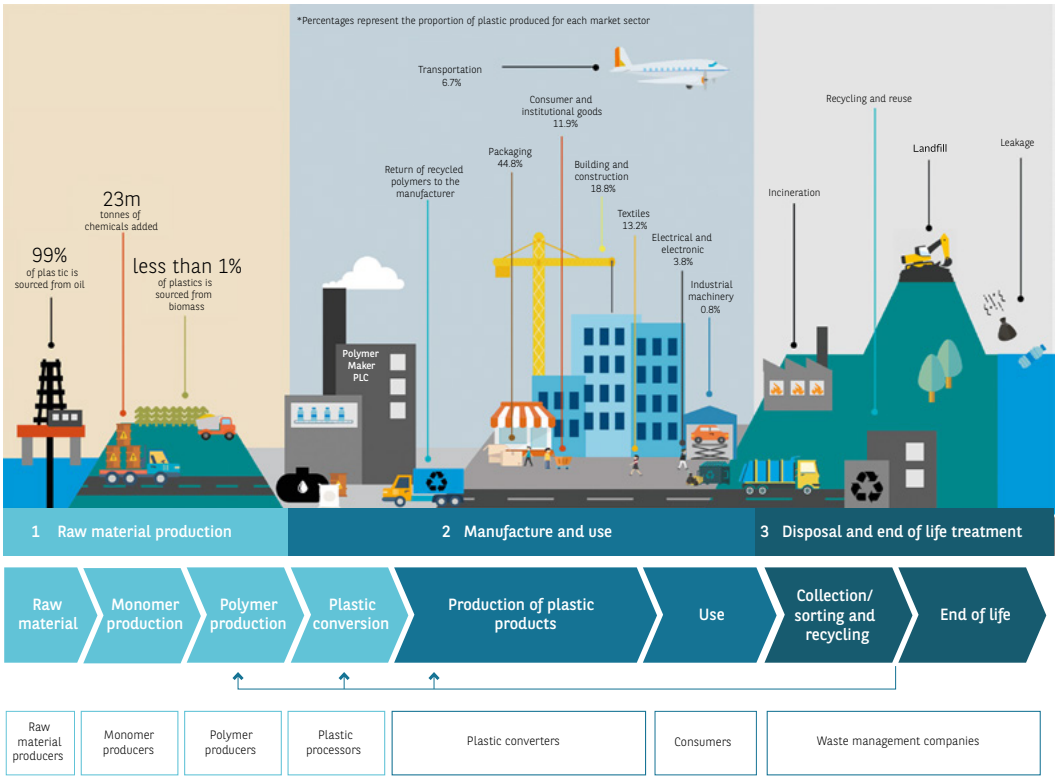
Oil & gas accounts for a total of 11% (see Exhibit 3) on a sectoral basis globally, with North America contributing the most at USD 486 billion (see Table 1). This is due to the potential cost of decommissioning 2.6 million unplugged onshore oil wells and 1.2 million undocumented wells, known as 'orphan' oil wells in the US[4], and substantial oil & gas exploration and production in Canada. Additionally, we identified USD 200 billion of decommissioning costs from Asia Pacific and the Middle East. However, relative to the UK Continental Shelf (or North America) where we have extensive transparency and available data, and relative to the importance of oil production in these regions, the total cost for oil & gas decommissioning in Asia Pacific and Middle East is likely to be higher.

Given that a sizeable proportion of global industrial production and mining occurs in Asia and is then exported to the rest of the world, the region accounts for 52% (see Table 1) of **shipping decommissioning** costs. We estimate the shipping costs based on countries with the ownership responsibility of a ship rather than where the ship is currently registered. Of global ship dismantling, 90% occurs in countries with low labour costs such as Bangladesh, China, Pakistan, Turkey and India, where the activity can have a high social and environmental impact[5].

The closure and rehabilitation costs of **landfills** is difficult to assess, but based on our estimates (relying on World Bank data), they account for about 8% (see Exhibit 3) of total decommissioning costs. However, it is important to note that this is only one element of waste management: the decommissioning of landfill sites dedicated to 'collecting/sorting and recycling' waste (as highlighted in Exhibit 4). Additional upstream or downstream decommissioning costs are not included.

5. Raw data and calculations for this report are available

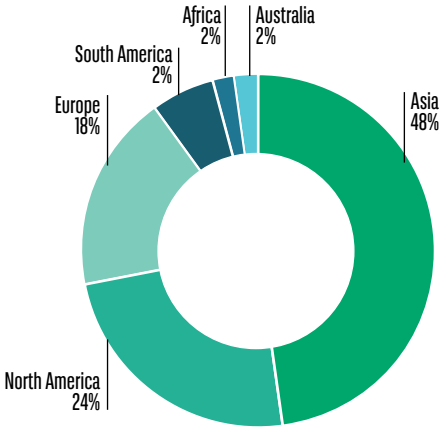
Exhibit 4: Plastics value chain



Source: Risks and opportunities along the plastics value chain | Engagement guide | PRI (unpri.org), 2019

Asia (48%), North America (24%) and Europe (18%) are the dominant regions as regards decommissioning costs (see Exhibit 5). Our analysis of the split of decommissioning costs by sectors across regions (see Exhibit 1 above), shows that nuclear has the highest decommissioning liabilities in North America and Europe, while oil & gas leads in Africa. Half of South America's decommissioning relates to mining, while in Asia, decommissioning costs are spread more equally across all sectors with the highest liabilities shared by renewables, nuclear and industrials.

Exhibit 5: Total decommissioning costs by continent



Source: BNP Paribas Asset Management, March 2023

In summary, the global costs of decommissioning expected to be incurred across all eight sectors have been assessed at almost USD 8.0 trillion, most of which will occur in Asia, North America and Europe and be concentrated in the nuclear, renewables and mining sectors.

DEFINITIVE SCALE AND RISKS OF DECOMMISSIONING FINANCIAL NEEDS REMAIN UNCERTAIN

We estimated decommissioning costs based on the prevailing technical requirements, settlement dates, inflation and discount rates and regulatory conditions at the time of writing. However, several factors could affect these estimates:

- **The transition to a lower carbon economy** requires business models to be reviewed and adapted. In recent years, oil & gas companies such as Shell[6] and BP[7] have begun to acknowledge the acceleration of the energy transition, resulting in earlier-than-anticipated decommissioning work and thereby increasing the current value of the associated liabilities.

- A 2016 report on mine rehabilitation and closure costs in Australia[6] showed that companies frequently **underestimate published initial decommissioning costs** as provisions often rise significantly later. For example, a case study in the report showed that a constant revision of the cost of rehabilitating the Ranger uranium mine rose from AUD 1 million in 2004 to more than AUD 600 million in 2016. Similarly, an Australian mining company experienced a tremendous increase in its closure provision purely based on cost revisions: from AUD 169 million in 2008 to AUD 805 million in 2015. A 2023 report by Carbon Tracker[7] shows that Engie, the global energy and renewables supplier company, experienced a proposed regulatory revision of nuclear provisions estimates by the Belgian Commission for Nuclear Provisions (CPN) from EUR 2.3 billion (Engie's estimate) to EUR 3.3 billion due to cost adjustments and discount rate assumptions. Whenever possible, we have sought to adjust the estimates based on average decommissioning costs (see next bullet point).

- **Decommissioning costs change with assumptions**: The cost of decommissioning the same asset can vary between jurisdictions. For instance, France estimates it costs EUR 300 million per gigawatt of generating capacity to decommission nuclear reactors - far below Germany's assumption of EUR 1.4 billion per GW and the UK estimate of EUR 2.7 billion per GW[8].

Exhibit 6: Estimated cost of decommissioning nuclear reactors per gigawatt (GW) of generating capacity

FRANCE	GERMANY	UNITED KINGDOM
€300m/GW	€1.4b/GW	€2.7b/GW

Source: Energy post, 2017

6. Shell annual report 2021 (page 222): *"The timing of estimated future decommissioning activity is also a key judgement with the energy transition increasing the risk that oil and gas fields will be decommissioned earlier than anticipated."*
7. BP annual report 2021 (Page 148): *"The timing of expected future decommissioning expenditures in respect of oil and gas assets may need to be brought forward with a resulting increase in the present value of the associated liabilities due to the impact of climate change."*

- **Skilled labour for decommissioning projects** faces a supply and demand imbalance in normal times. Should decommissioning programmes be accelerated (either for strategic purposes or because of strong market and societal pressures to close polluting infrastructures), the risk is high that actual decommissioning costs could increase substantially. A 'run for the green door' could have dire financial consequences for companies laden with decommissioning liabilities.

- Finally, **regulatory standards** change rapidly, and health and safety risks can materially affect costs over time and would particularly affect large offshore oil & gas and mining production sites.

    - **Safety risks:** Ageing infrastructure may become (and in some cases already has become) unsafe for workers or the public. Without proper decommissioning, there may be a risk of accidents, fires or greater pollution that could cause injuries, property damage or even fatalities.

    - **Environmental and public health risks:** Assets such as offshore oil rigs, pipelines or nuclear power plants may pose significant environmental risks if not properly decommissioned. The longer the assets are left unused, the greater these risks (for example, oil spills, contamination of soil or water, radiation leaks and release of greenhouse gases into the atmosphere).

- The **only potential mitigating factor** is technology. Indeed, decommissioning, remediation and rehabilitation costs could fall if more sophisticated and cost-efficient approaches are discovered and used.

We conclude that the current roughly USD 8.0 trillion estimate is likely below the real decommissioning costs incurred by all actors when the bill comes due. For that reason, the following risks should not be underestimated.

- **Shortfall risk:** Oil & gas, mining, power and other companies may not be able to meet their decommissioning costs with their free cash flows. Indeed, given the volatility of revenues (and in particular of commodity and energy prices), historical analysis shows that relying only on free cash flow is often not enough (see Case Study 1).

- **Financial risks:** Assets that are not properly decommissioned may result in significant ongoing costs such as maintenance or insurance that could impact the financial health of the owner or operator. Additionally, the cost of decommissioning an asset looks likely to rise over time, so delaying the process may result in higher costs in the future. This significantly boosts the risk of an adverse impact on a company's credit and ESG ratings.

- **Legal risks:** Partially decommissioned assets may lead to legal liability for the owner or operator. For example, failure to decommission an oil rig may result in fines or legal action from government agencies or local communities.

- **Reputational risks:** Failure to properly decommission an asset may damage the reputation of the owner or operator, leading to loss of business or a negative public perception.

In summary, failing to adequately prepare for the decommissioning of old, polluting assets may have significant impacts on the environment, safety, legal liability, financial health and reputation of the owner or operator. Effective decommissioning is an important process that should be carefully funded, planned and executed to mitigate these risks.

HOW DECOMMISSIONING PRE-FUNDING IS CURRENTLY MANAGED AND THE RISKS INVOLVED

THE CURRENT STATE OF PRE-FUNDING DECOMMISSIONING REGULATIONS ACROSS SECTORS AND COUNTRIES

Nuclear decommissioning is complex and expensive and requires significant financial and operational resources to ensure it is carried out safely and effectively. To finance nuclear decommissioning, many countries have established regulatory frameworks that require operators to set aside funds in dedicated decommissioning provisions. For instance, the US Nuclear Regulatory Commission (NRC) requires operators to set up a decommissioning trust fund, while operators with smaller decommissioning liabilities (below USD 113 000) do not need to set funds aside, but they must give financial assurances such as surety bonds, letters of credit or other financial guarantees[9]. Other regulations include the maintenance of a financial guarantee for decommissioning in Canada[10]; Sweden (Nuclear Waste Fund)[11]; Belgium (decommissioning fund)[12] and the UK[13].

Regulations for decommissioning in the oil & gas sector are evolving through similar frameworks. Indeed, many countries have enacted pre-funding laws; China[14], Angola[15], Ghana[16], India[17], and Nigeria[18] are examples. However, unlike the nuclear sector, many countries still lag in regulations to ensure the pre-funding of decommissioning obligations. For example, none of the countries with stakes in the North Sea's oil & gas fields and wells has made pre-funding of decommissioning liabilities compulsory; they only require third-party financial guarantees such as letters of credit and surety bonds. Pre-funding could limit the risk that decommissioning costs are not met when they come due.

Some countries and regions have passed regulations pertaining to the setup of mining decommissioning reserve funds such as South Africa[19], Yukon in Canada[20], and the Netherlands[21]. Similarly, the Netherlands has a dedicated fund to finance and manage the aftercare of closed landfills[22].

Changes to regulations (as well as strategies) have led companies operating in the oil & gas, mining and landfill sectors to start funding decommissioning reserve funds - among them CNOOC[8], Goldfield limited[9] and Renewi PLC[10]. However, most companies still pay decommissioning costs out of operational cash flow. Where decommissioning funds exist, the level of pre-funding often falls short as it is rarely sufficient to fully cover the estimated decommissioning costs, and as illustrated above, such costs are frequently underestimated when reported on companies' balance sheets[23].

8. CNOOC annual report 2021 (Page 136): *"...makes monthly cash contributions to the specified dismantlement fund accounts."*
9. Goldfield Limited annual report 2021 (Page 160): *"For the South African and Ghanaian operations, annual contributions are made to a dedicated rehabilitation trust fund and dedicated bank account, respectively, to fund the estimated cost of rehabilitation during and at the end of the life-of-mine."*
10. Renewi PLC annual report 2022 (Page 207): *"The Group is required to provide the funds to the province which are then administered and controlled by the province per landfill location".*

WHY IS PRE-FUNDING DECOMMISSIONING LIABILITIES BECOMING A CRITICAL FACTOR FOR COMPANIES' BUSINESS STRATEGY?

The need to pre-fund decommissioning activities is critical as companies progress through the energy transition and adopt stricter ESG policies; concurrently, the risk of shortfall rises with the withdrawal of support from financial institutions.

- **The energy transition is accelerating.** Beyond the adoption of new sources of energy, there is an accelerated need to decommission old sources of energy, oil & gas, mining and previous industrial technologies.

  - The aim is to support a smooth transition to the adoption of renewables. Many countries are changing their industrial infrastructure by speeding up the implementation of innovative technologies. In effect, in some sectors, this goes beyond ensuring that the decommissioning phase is fully and successfully completed at the end of the asset's life: sectors such as coal are under pressure to undertake earlier-than-planned decommissioning activities.

  - Decommissioning is now playing a critical role in mergers & acquisitions, particularly those involving businesses operating in the North Sea. It is worth noting that in many cases, the sale of oil & gas assets is net of decommissioning costs. Deals often require the seller to retain part or all of the decommissioning liabilities.

  - There is growing interest in alternative energy transition investment approaches. For instance, private equity funds in the US dedicated to the decommissioning of polluting assets acquire 'brown' assets against the payment of a lump sum for taking on the liabilities. They aim to optimise the decommissioning process and repurpose and redevelop the remaining infrastructure and land into sustainable/green investments.

- **The scale of adoption of ESG policies** in recent years is making it difficult for companies if they are perceived to be not actively managing pollution and environmental risks.

  - Since 2015, when countries gathered at COP21 to sign the Paris Agreement and agreed to aim to curb the average increase in global warming to between 1.5 and 2 degrees Centigrade, companies and governments have stepped up efforts to build a more sustainable and equitable future. Governments are adopting policies and implementing regulations for a sustainable future. In Germany, for instance, the government aimed to phase out nuclear energy by 2022[24], however, due to the energy crises caused by the Ukraine war, the usage of nuclear power was extended[25]. In 2019, the Ultra-Low Emission Zone was introduced in Central London to help reduce toxic air pollution and preserve public health[26]. Similarly, the UK government plans to ban the sale of new petrol, diesel or hybrid cars in 2035 in line with its 2050 zero carbon emissions commitment[27].

  - ESG norms and rules adoption is impacting the financials sector. Banks have changed their lending and investment practices using negative and positive screening[11], thematic investing, ESG engagement, and the creation of sustainable finance frameworks[28]. Major banks have cut their fossil fuel financing[29].

11. Negative screening is a popular ESG investment approach where stocks of companies seen as 'unsustainable' are excluded from the funds. The strategy excludes stocks of companies involved in tobacco, alcohol, weapons and fossil fuels. Among the sectors covered in this report, Oil & gas, coal and nuclear stocks are subject to exclusions.

- Credit rating agencies now integrate ESG factors into their methodology (including the treatment of decommissioning liabilities)[30]. They consider the impact of these liabilities on energy and mining companies' ratings in various ways: 1) As part of the net debt taking into account the underlying regulation in the relevant country; 2) All agencies take decommissioning as orphan liabilities included in the net debt if the matching operational assets are sold; 3) Decommissioning liabilities affect Moody's qualitative environmental rating.

- Shareholders and investors are focusing on the sustainability of their investments. According to the Global Sustainable Investment Alliance 2020 report, ESG assets under management reached USD 35.3 trillion, up by 15% in two years, equating to 36% of all professionally managed assets across the US, Canada, Japan, Australia, Asia and Europe[31]. Bloomberg forecasts that ESG assets will exceed USD 50 trillion by 2025, representing more than one third of the projected USD 140.5 trillion in total global AUM[32].

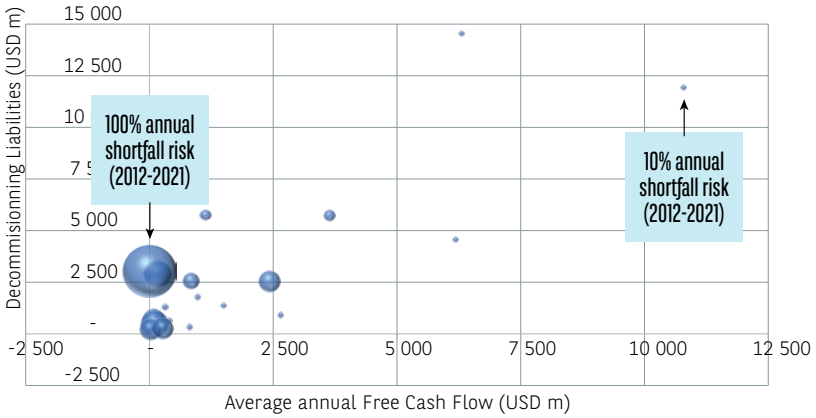
- Wide-scale decommissioning/restoration/rehabilitation of soil, sea and air accompany the energy transition objectives of COP 26. Funding these activities requires the use of dedicated financing instruments with a strong governance and management framework. Decommissioning bonds could be an answer to those needs.

Case study 1: Mining companies' capacity to meet decommissioning costs

Analysing the free cash flows and decommissioning liabilities of 19 global mining companies, we found that over the last 10 years:

- The average annual free cash flow for the sample is lower than the smoothed (over 20 years) decommissioning liabilities
- For each company, smoothed decommissioning liabilities are not always met on an annual basis through free cash flow (they vary between 10% and 100% of probability of shortfall between 2012 and 2021 depending on the company). Larger companies with larger free cash flows (and larger decommissioning liabilities) appear to be at less risk than smaller companies. This assessment does not consider changing inflation expectations as well as changing environmental standards that may further affect decommissioning costs.
- Pre-funding the decommissioning liabilities and benefiting from market returns (uncorrelated to the mining company's revenues) can help reduce the probability of shortfall.

Average annual free cash flow & decommissioning liabilities vs. probability of annual shortfall



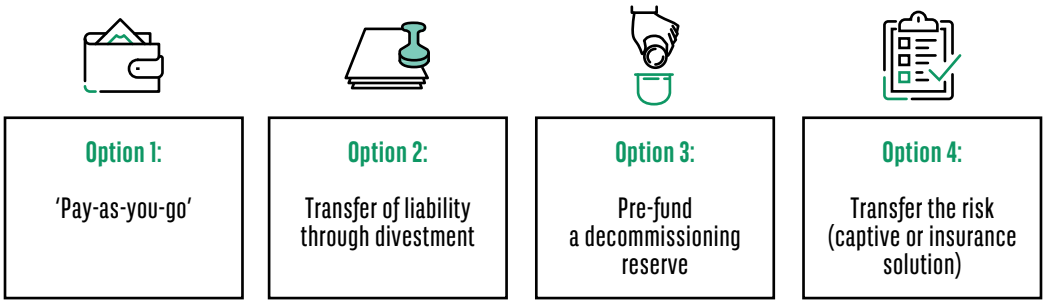
Source: BNP Paribas Asset Management, Bloomberg, Annual Reports, December 2022

FINANCING DECOMMISSIONING AND BEYOND

A RANGE OF PRE-FUNDING SOLUTIONS TO ENSURE DECOMMISSIONING LIABILITIES ARE MET

As explained in Section 2, companies in Asia, North America and Europe should take action to protect themselves against decommissioning costs. Pre-funding is an efficient approach to managing decommissioning risks. There are several implementation options. Companies in the nuclear, oil & gas, mining and landfill sectors are already pre-funding their decommissioning liabilities. We believe pre-funding is highly beneficial for any company exposed to long-term liabilities.

Different approaches to managing decommissioning liabilities



Benefits of pre-funding decommissioning liabilities (Options 2 to 4)

- **Increases cash flow:** Investment returns can provide part of the financing of the liabilities and can be tax efficient.
- **Improves risk management:** The use of a trust/captive reinforces risk management and reduces the risk of a shortfall.
- **Enhances the efficiency of matching liabilities:** Pre-funding allows for long-term investment that can generate returns to match the required future liabilities. The decorrelation of commodity prices and financial assets offers diversification benefits.
- **Lowers financing costs:** The standing with banks improves with the potential for lower costs of letters of credit. It can also improve ESG and debt ratings and lower borrowing costs for the organisation as a whole.
- **Creates flexibility:** It delivers optionality in an uncertain future and provides flexibility of risk transfer in both amount and timing.
- **Improves relationship with stakeholders:** It offers the prospect of an improved standing with regulators and investors and reinforces emerging sustainable values.

LESSONS FROM THE PRE-FUNDING OF PENSION FUND LIABILITIES

Institutional investors such as pension funds and insurance companies seeking to match their liabilities have historically implemented leveraged and non-leveraged liability-driven investment (LDI) portfolios of government bonds, repurchase agreements (repos) and swaps which allow for a greater market exposure than would be possible from the value of the physical assets. The 2022 LDI crisis in the UK has led many to question the use of leverage, bringing a sharper focus on cash flow-driven investment (CDI), where cash flows are appropriately matched using physical assets. In this context, BNP Paribas Asset Management has supported the use of private markets (potentially blended with corporate and government bonds) to match long-term liabilities while offering both diversification and return benefits relative to traditional public assets.

Illiquid assets such as Dutch mortgages and infrastructure debt allow institutions to match long-term liabilities while lowering portfolio volatility (as valuations are not typically marked to market) and offering enhanced returns. Over time, enhanced returns further reduce the contributions that institutions are required to make to meet their long-term liabilities. This approach is just as relevant to an industrial company seeking to match long-term decommissioning liabilities as it is for a pension fund or an insurance company. A typical CDI investment universe is shown below, created for the client's particular circumstances (e.g., tenor, currency, geography, risk/return appetite). Exhibit 7 provides a high-level summary of the components of a cash flow-matching investment strategy for decommissioning liabilities.

Exhibit 7: Fixed-income assets for a decommissioning cash flow-matching investment strategy

	First 5 years	5 to 10 years	10 to 15 years	15 years and above
Liquid fixed-income assets	• Money market funds • MBS • ABS • CLOs • Corporate bonds	• MBS • ABS • CLOs • Corporate bonds	• Government bonds	• Government bonds
Illiquid fixed-income assets	• SME loans • US mid-market loans	• Commercial real estate debt (senior and junior)	• Infrastructure debt	• European mortgages

Source: BNP Paribas Asset Management, June 2023

BEYOND DECOMMISSIONING – DIVERSIFYING BUSINESS MODELS AS CORPORATIONS PIVOT

For many oil & gas (as well as power, industrial, chemical and transport) companies, even if they meet their decommissioning liabilities over time, they may not remain relevant to the global post-energy transition economy. In this context, these companies have begun to pivot their business models to maintain viability and relevance, but also to maintain access to shareholder capital and capital markets.

However, this transition has been slow. One reason is the pace of change and the breadth of new technologies being offered as potential solutions. For example, as we examine renewable energy production, beyond the obvious benefits of the greater use of solar, wind and hydro to produce energy, it is not obvious which technologies will become dominant in the future (in the case of hydrogen or carbon capture, for example) or how best to access them at this stage in their development. Additionally, funding renewable energy production, decarbonisation and other sustainable investments does not always follow a clear pattern, but requires the use of various investment vehicles and/or asset classes.

Exhibit 8: How to gain exposure to the decarbonisation, sustainability and energy transition themes

Themes	Best suited asset classes
Decarbonisation technologies and high impact investments	Private equity / Venture capital / Listed equities
Large-scale climate adaptation and changes	Infrastructure equity / Infrastructure debt
Carbon sinks and decarbonisation of agriculture	Forestry funds / Private equity
Focus on low carbon emissions corporates	Listed equities / Listed bonds
Carbon market exposure	Carbon credits and sustainable commodities

Source: BNP Paribas Asset Management, June 2023

As companies struggle with emergent technologies, BNP Paribas Asset Management has developed an approach to financing the energy and sustainability transition that creates a diversified portfolio of sub-themed exposures, allowing corporates to invest in early-stage technologies with a view to increasing the weight of these over time as these themes develop. Critically, these are listed and unlisted investments that may ultimately lead to formal M&A activity, allowing business models to pivot as government regulations and technologies mature. For now, it is clear to us that pre-funding decommissioning liabilities is a prudent approach that can develop over time in the strategic review of business models.

APPENDIX

ASSUMPTIONS AND LIMITATIONS OF A DESK STUDY FOR ESTIMATING THE DECOMMISSIONING LIABILITIES

Our analysis to determine the decommissioning liabilities estimate is based on the following criteria and assumptions:

- The eight sectors in scope are nuclear, coal power, renewable energy, industrials, mining, shipping, oil & gas and landfills

- The assets accounted for in each sector range from nuclear facilities, coal power plants for coal; wind turbines, solar plants and hydroelectric dams for renewable energy; chemical plants and heavy manufacturing plants for industrials; mine sites, commercial shipping fleets, oil & gas producing facilities and landfill sites

- Data sources:

    - When available, we first compile decommissioning reports published by reputable organisations to form the basis of our estimation. For instance, in 2022, the North Sea Transition Authority estimated the oil & gas decommissioning liability in the UK Continental Shelf to be GBP 44.5 billion[44]
    - Where reports stating the decommissioning liabilities in a region/country were not available, we used our own hypotheses and indicative interpolations
    - In addition to the above data methodology, companies' annual reports for decommissioning provisions were taken for the oil & gas sector where published reports on estimated liabilities within a specific country were not available. For example, the figures for oil & gas decommissioning liabilities for Mexico are derived from PEMEX 2021 provisions for asset retirements (annual report).[12]

- Decommissioning estimates consider the standard operating lifespan of an asset (see Table 2). For assets with an operating life longer than 30 years, the numbers are averaged using an assumption factor to narrow down the liabilities to expected costs to be incurred between 2023 and 2053. In particular, this adjustment was made for hydroelectric dams with the highest standard lifespan of 50 to 100 years; other sectors were not adjusted.

We encountered some limitations while making our analysis:

1. Due to the lack of reports stating the scope of decommissioning for some sectors, we used assumptions and interpolations to estimate decommissioning costs

2. Due to the lack of data available e.g., oil & gas data in Africa and the Middle East or mining in Africa and Australia, their decommissioning costs are likely to have been underestimated in some regions

3. Our analysis is based on average decommission costs. However, in practice, these costs can vary due to regulation, health and safety standards, size, location, technology, labour capacity and other specific requirements.

12. PEMEX 2021 Form 20-F, provisions for sundry creditors, page F-99.

Table 2: Standard lifespan of decommissioning sub-sectors

SECTORS	SUB-SECTORS	STANDARD LIFESPAN
Renewable energy	Wind turbines	20 years [35]
	Solar plants	20 - 30 years [36]
	Hydroelectric dams	50 - 100 years [3]
Nuclear	Nuclear plants	40 years[37]
Oil & gas	Oil & gas wells	20 - 40 years[38]
Coal	Coal power plants	35 - 60 years[39]
Mining	Mines	30 - 50 years[40]
Industrials	Chemical plants	> 47 years[41]
	Heavy industries	> 47 years[41]
Shipping	Shipping fleets	20 - 25 years[42]
Landfill	Landfills	30 - 50 years[43]

Source: BNP Paribas Asset Management, June 2023

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SOURCES FOR DECOMMISSIONING COST ESTIMATES

RENEWABLE ENERGY

Wind turbines

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Heavy industries

S/N	Link	Author	Year
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